Application Of: Jeffrey S. Pyle

For: System and Method for Synchronous Sampling and Asynchronous Transfer of Data With Connectionless Powering and Control of Data Link Subsystems

BACKGROUND OF THE INVENTION

[0001] The present invention relates to collection and transmission of data corresponding to one or more physical, electrical, environmental, or other parameters at discrete points over an area where discernment of such parameters is desired. More particularly, the invention relates to improvements in the electrical powering and control of subsystems having a plurality of sensor arrays for responding to stimuli present at such arrays and for transmitting RF signals commensurate with the stimuli to an end user.

[0002] Current systems for measuring parameters such as sound wave energy over a designated area include so-called Towed Array hoses wherein an elongated tube or cylinder containing a plurality of acoustic sensing devices in spaced relation along its length is towed behind a ship or other moving vehicle. The sensing devices comprise appropriate transducers for converting the acoustic energy to commensurate electrical signals capable of radio transmission. Direct electrical connection between the power source and the physical layer within such acoustic arrays is required for supplying electrical power to the acoustic and non-acoustic subsystems; direct connection is also required for data transfer telemetry sub-systems. These connection points and interconnecting wiring harnesses are subject to failure. In fact, the majority of non-operational failures in such systems appear to be the result of damage to conductors and/or physical connections.

[0003] It is a principal object of the present invention to provide systems and methods of improving reliability of communications and power links within parameter sensing and transmission subsystems.

[0004] Another object is to improve scalability in data collection systems employing synchronous sampling of parameter values and asynchronous transmission of the collected data.

[0005] A further object is to provide an array of sensors for sampling the value of one or more variable parameters at a desired rate and transferring data commensurate with such values wherein electrical power, control of sampling rate and transfer of data are carried out without physical contact to any wiring harness.

[0006] Still another object is to provide a structural arrangement of elements for use in a towed array acoustic sensing system which results in improvements in reliability, scalability and manufacturing costs when compared with prior art systems of this type.

[0007] Other objects will be obvious and will in part appear hereinafter.

SUMMARY OF THE INVENTION

[0008] In furtherance of the foregoing objects, the invention comprises a physical support member, such as a length of cylindrical tubing of dielectric material, with a single, insulated, electrical conductor and a coaxial cable extending in spaced, substantially parallel relation through the tubing for all or most of its length. The tubing may be hollow, in the nature of a hose, or solid with the conductor and cable extending through the open, central part of the tubing or embedded in the dielectric material. The insulated conductor is surrounded by a plurality of toroidal coils forming current transformers at spaced positions along the length of the conductor. The insulated

conductor is connected to a source of AC power and, when energized, provides potential energy across the terminals of the current transformers.

[0009] A plurality of microcells, preferably equal in number to the current transformers, is also mounted to the tubing, within the hollow central portions or embedded in the material thereof. In the disclosed embodiment, each microcell includes a phase locked loop, an A/D converter and a sensor package, connected in series, with the terminals of the current transformer providing an input to the phase locked loop which is a function of the wave form on the insulated conductor. Each microcell further includes an induction power regulator which receives power from the terminals of the current transformer and is connected to a control rectifier which, in turn, provides DC power to acoustic and non-acoustic subsystems of the microcell. The sensor package or array generates electrical signals in response to, and commensurate with, a parameter such as sound energy at the location of the array. The signals are stored in a local data storage device within the microcell and, upon command from a control node connected to the coaxial cable, are transmitted by a Federated Radio System (i.e., an RF transmitter with directional antenna associated with each microcell) for reception at a remote location where the parameter values at the respective sensor arrays are monitored. The coupled-mode coaxial cable is optimized to the frequency of the radio transmitters. The control node is mounted in the tubing structure and creates control information required for structured TDMA operation.

[0010] The foregoing and other features of the system and method of the invention will be more fully described and explained in the following detailed

description, taken in conjunction with the accompanying drawings which are partly schematic and partly diagrammatic in content.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figures 1A and 1B are diagrammatic overviews of a typical prior art system and a system of the present invention, respectively, for purposes of direct comparison of the portions of each system which are of interest herein;

[0012] Figures 2A and 2B are illustrations of the general physical arrangement of elements in the disclosed example of the invention, shown in smaller scale and more general terms in Figure 2A and larger scale with more detail in Figure 2B;

[0013] Figure 3 illustrates one of the elements of Figures 2A and 2B in association with other elements;

[0014] Figure 4 is a portion of Figure 3 shown in association with still more elements;

[0015] Figure 5 illustrates the functional relationship between portions of previous Figures with an additional element; and

[0016] Figure 6 illustrates flow of information between portions of the system.

DETAILED DESCRIPTION

[0017] As stated, the invention is concerned with monitoring data associated with the condition or value of some variable parameter(s) in a designated location at discrete points in time. The present discussion will be directed to systems wherein the monitored parameter is sound energy, although it will be understood that more than one parameter may be monitored, and that the parameter may be something other than sound energy. At any rate, such monitoring systems have typically included a plurality of sensor arrays,

arranged in channel groups such as those denoted in Figure 1A by reference numeral 10, each physically connected by a wiring harness 12 to a multiplexer and/or hub 14. Each wiring harness 12 includes wires for power, signaling, etc. woven in the same harness. Clocking signals emanating from hub 14 are propagated along the wires of wiring harnesses 12 to synchronize sampling of the parameter value and transmission of electrical signals commensurate with the sensed values to hub 14. Thus, supply of power to the acoustic and non-acoustic subsystems of arrays 10, as well as control and transmission of data requires physical connection of a large number of individual wires to the sensor arrays and hub.

[0018] The present system, by contrast, does not require, nor does it employ, the physical connections of a wiring harness between the channel groups and hub for either power or signaling purposes. As shown in Figure 1B, the system includes a plurality of channel groups and a hub, as in the prior system, but the wiring harness which physically connected these elements is replaced by a single, insulated conductor 18, connected at one end to main power supply 20, and a coaxial cable 22. The elements corresponding to channel groups 10 of Figure 1A are termed "microcells" and denoted by reference number 16, and the element corresponding to hub 14 is termed "control node" 24, for reasons which will become apparent. Microcells 16 are inductively powered by current transformers (shown in Figures 3 and 4) having toroidal cores through which insulated conductor 18 passes, whereby power and synchronous sampling signals are provided from main power supply 20. Additionally, clocking and data signals are coupled into and out of trunking cable 22, a coaxial cable in coupled mode connected to control node 24, extending along the length of the towed array in close proximity to microcells 16.

[0019] An example of a physical association of elements embodying the system of the present invention is shown in Figures 2A and 2B. Elongated tube 26, formed as a hollow, cylindrical body of a suitable, dielectric material, is adapted for connection to a towing vehicle or other movable object. Insulated conductor 18 and coupled mode coaxial cable 22 extend in spaced, parallel relation through the open, central part of tube 26 for all or most of its length. Conductor 18 is connected at one end to the main power supply 20, such as a conventional generator preferably located on or mounted to the towing vehicle, and coaxial cable 22 is connected to control node 24, preferably within or mounted to tube 26. As indicated in Figure 2A, a plurality of identical microcells 16 are mounted in, or to tube 26, either within the open, central portion thereof or embedded in the material of the tube wall. That is, depending upon the preferred design, the elements may or may not be directly attached to the tube wall. Each of microcells 16, as shown in Figure 2B, includes an RF transmitter with directional antenna 34 for conveying data in the form of pulse bursts of digital signals between control node 24 and microcells 16. The radios and other components of the several microcells 16 collectively make up what is known in the art as a Federated Radio System which, as will be seen, collect data in their respective locations synchronously and transmit such data asynchronously, i.e., when commanded to do so by control node 24.

[0020] As shown in Figure 3, insulated conductor 18 passes through the open centers of the toroidal windings of a plurality of current transformers 36, equal in number to the number of microcells 16. Thus, when conductor 18 is energized to carry AC current, potential energy, proportional in value to the value of the current on conductor 18, is available at terminals 38 of the windings. Figure 4 illustrates two of the current

transformers 36 and the connection of terminals 38 thereof to elements of microcells 16. Terminals 38 are connected to phase locked loop 40 which provides a signal to A/D converter 42 commensurate with the frequency of the AC waveform on conductor 18. The sensor group or array, e.g., a plurality of acoustic transducers, is indicated in Figures 2B and 4 by reference numeral 44 and receives signals from A/D converter 42. In this manner, the frequency of the AC on conductor 18 forms the basis of the sampling clock, that is, the sampling rate is controlled as a function of the design of phase locked loop 40. Terminals 38 are further connected to induction voltage regulator 46 and control rectifier 48 to provide DC power at terminal 50, thereby providing inductive (connectionless) powering of acoustic and non-acoustic subsystems. The foregoing description provides an operative embodiment of a circuit configuration and elements thereof suitable for use in the context of the present invention, although circuitry employing other elements will be apparent to those skilled in the art.

[0021] Referring now to Figure 5, the TDMA connectionless data transfer system comprises control node 24, coupled mode coaxial cable 22 and microcells 16. As previously stated, each of microcells 16 includes RF transmitter(s) 34 which make up the federated radio system. Connectionless data transfer is facilitated by the single, coupled mode, coaxial able 22 passing in proximity to the transmitters of each microcell and optimized to the frequency of the transmitters. RF signals carrying the acoustic and non-acoustic data are coupled into cable 22. The coupling efficiency is improved by designing the shield layer of cable 22 to permit a controlled amount of leakage and ingress. Data generated by sensor arrays 44 is stored locally, i.e., at each of microcells

16, in an appropriate memory device 52. Data generation and storage continues and remains passive until an activating signal is received from control node 24.

[0022] A file is compiled with a unique identifying code assigned to each of microcells 16, as well as appropriate Section and Line Overhead. When it is desired to retrieve data from the system, the appropriate command is delivered to control node 24. Control node 24 sends a command/synch packet destined for the microcell 16 which has the desired data. This packet contains several lines, with each line representing a unique TDMA slot. Although all microcells receive the packet, each packet contains a microcell ID and the type of data it is to transmit (packet size, data rates, acoustic data values, etc.). Control node 24 parses the first line of the command file and sends a command/synch packet destined for the microcell specified in the command file. All microcells receive the packet and interrogate it for microcell ID. The microcell designated in the command file decodes the command and transmits the data requested in the command. Control node 24 receives the incoming data stream from the designated microcell, parses it and records the data which is then transferred to media access converter 54 for transmission to the end user. The next command file is then transmitted and the cycle is repeated. This dialog between control node 24, microcells 16 and media access converter 54 is basically as set forth in Figure 6.

[0023] The control node and microcell software is designed to keep the two synchronized with all of the control being left up to the control node. This results in a self-synchronized TDMA data transfer system with the base TDMA slot determined by the combined processing delay of the control node, microcell and transmission latency. The invention provides electrical power and transmission of synchronously sampled

sensor intelligence without conventional physical contact to transmission or powering media. Power is derived from the magnetic field surrounding a single, insulated conductor carrying AC current. The frequency of the signal on the conductor, which may be either CW or pulsed, is the locking signal for a phase locked loop for synchronous sampling by the spaced sensor arrays.